



# **Armed Forces College of Medicine AFCM**



# **Spinal Cord**

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# INTENDED LEARNING OBJECTIVES (ILO)



**By the end of this lecture the student will be able**

**to:**

- 1- Describe the internal structure of spinal cord
- 2- **Correlate the different lamination of gray matter to their nuclear content**
- 3- Differentiate between the different levels of spinal cord

# Lecture Plan



**1. Part 1 (5 min)** Introduction to the spinal cord

**2. Part 2 (35 min)** Main lecture:

- General topography
- Spinal cord structure
- Spinal cord nuclei
- Lamination of spinal cord
- Spinal cord levels

**3. Part 3 (5 min)** Summary

**4. Lecture Quiz** (5 min)

# Nervous system

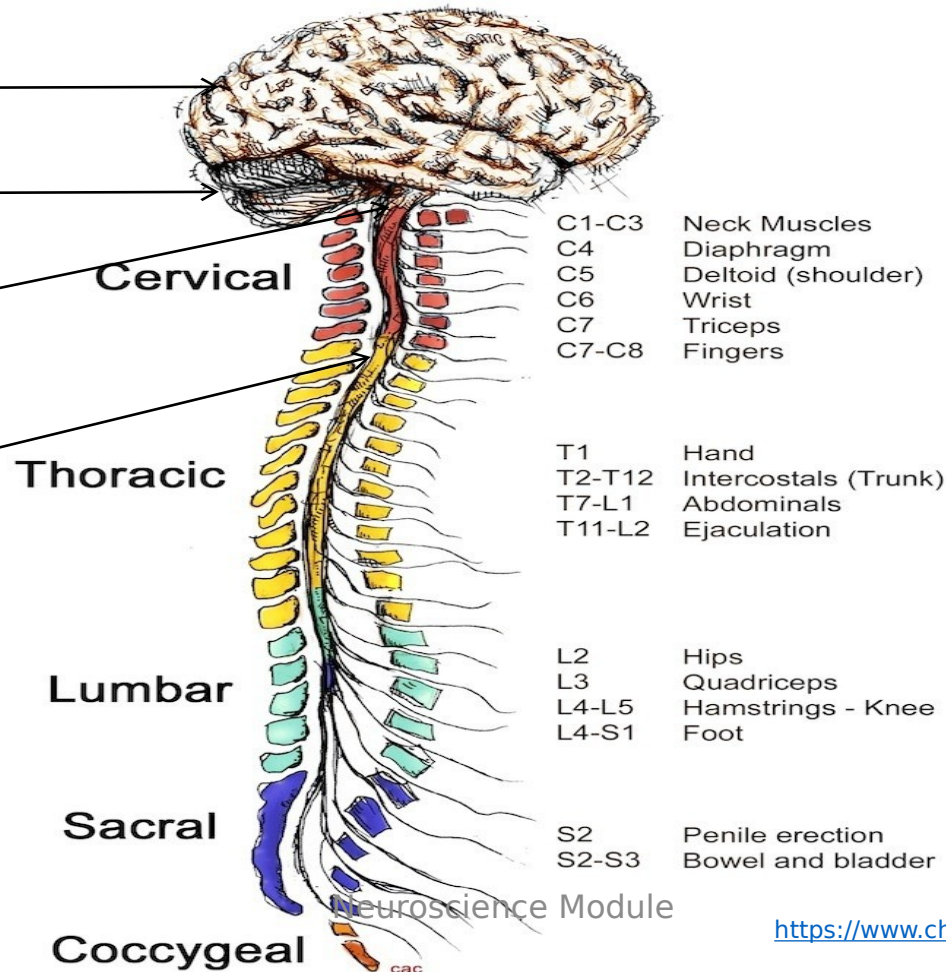


## Central nervous system

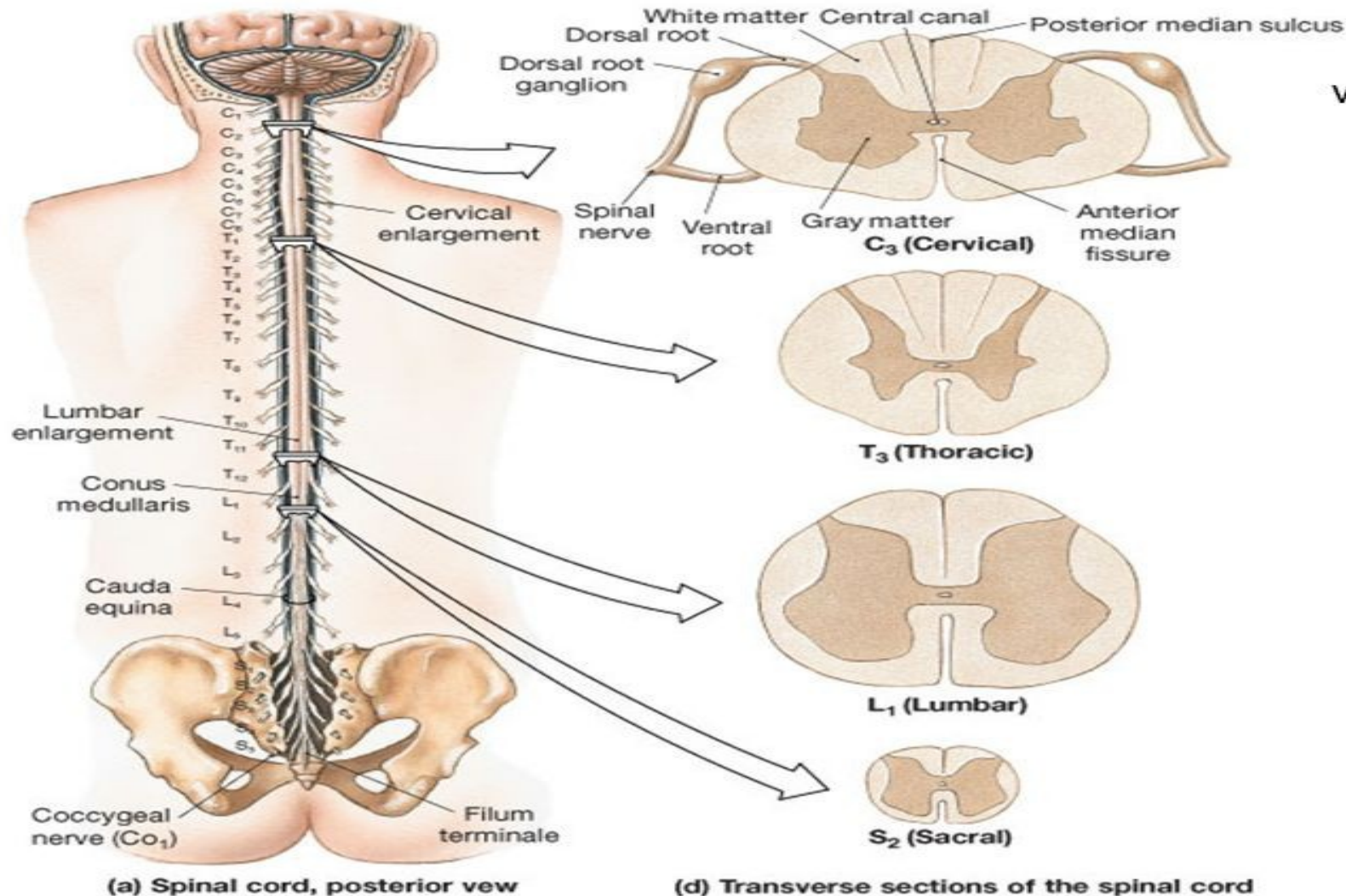
## Peripheral nervous system

Cerebrum  
Cerebellum  
Brain stem

Spinal Cord



# Spinal cord



white matter = columns  
gray matter = horns

## 31 pairs of Spinal Nerves

- 8 Cervical (C<sub>1</sub>-C<sub>8</sub>)
- 12 Thoracic (T<sub>1</sub>-T<sub>12</sub>)
- 5 Lumbar (L<sub>1</sub>-L<sub>5</sub>)
- 5 Sacral (S<sub>1</sub>-S<sub>5</sub>)
- 1 Coccygeal (Co<sub>1</sub>)



# General topography of the spinal cord



2 symmetrical halves

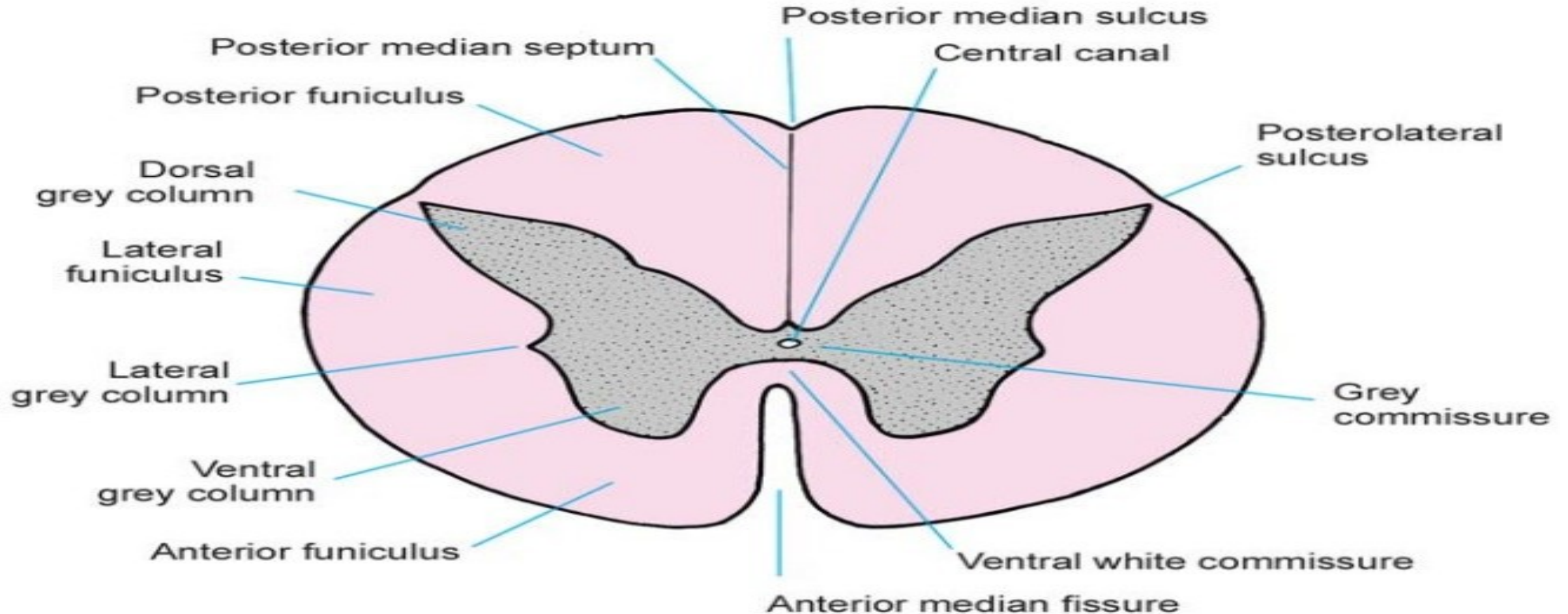
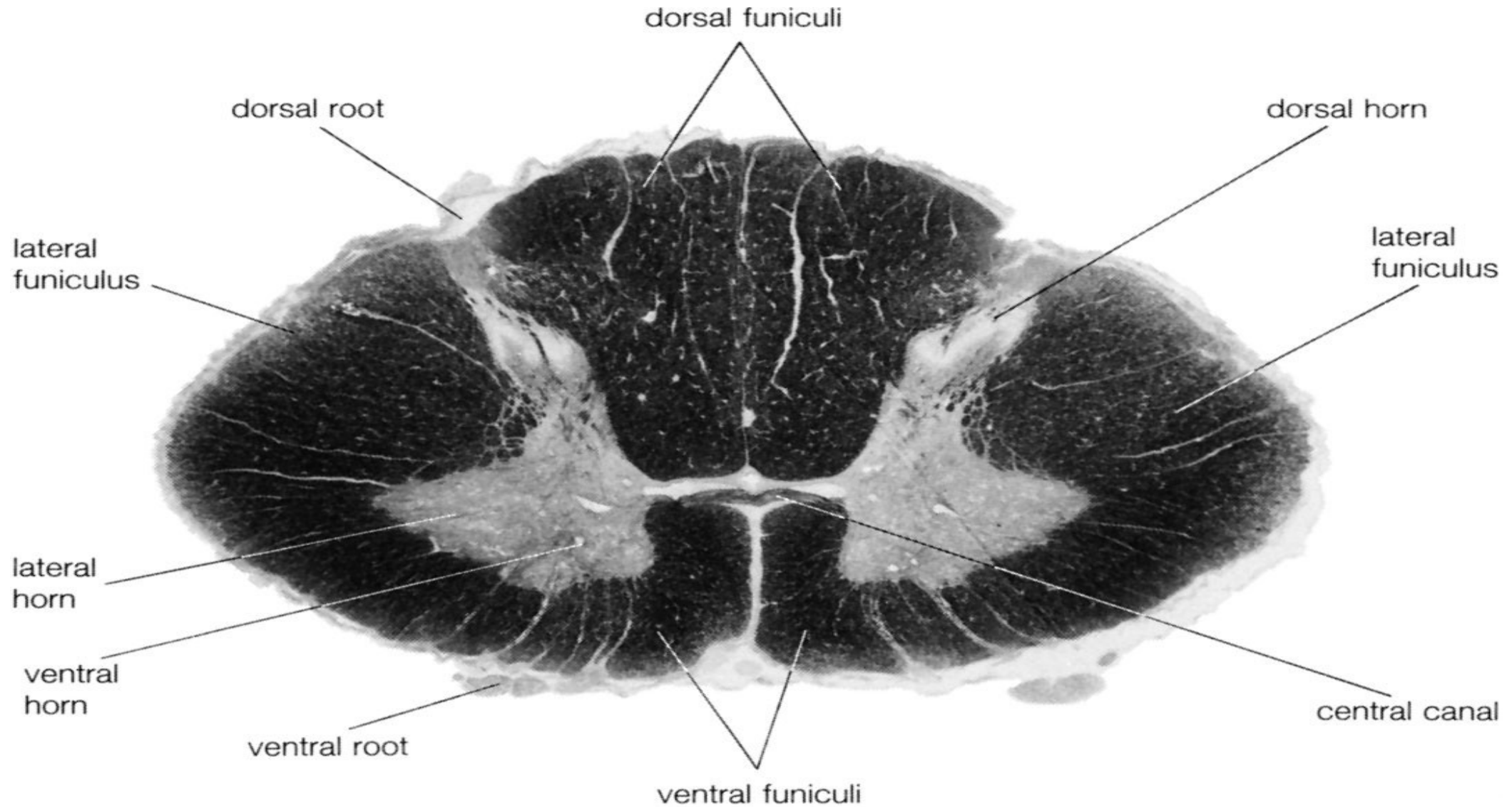


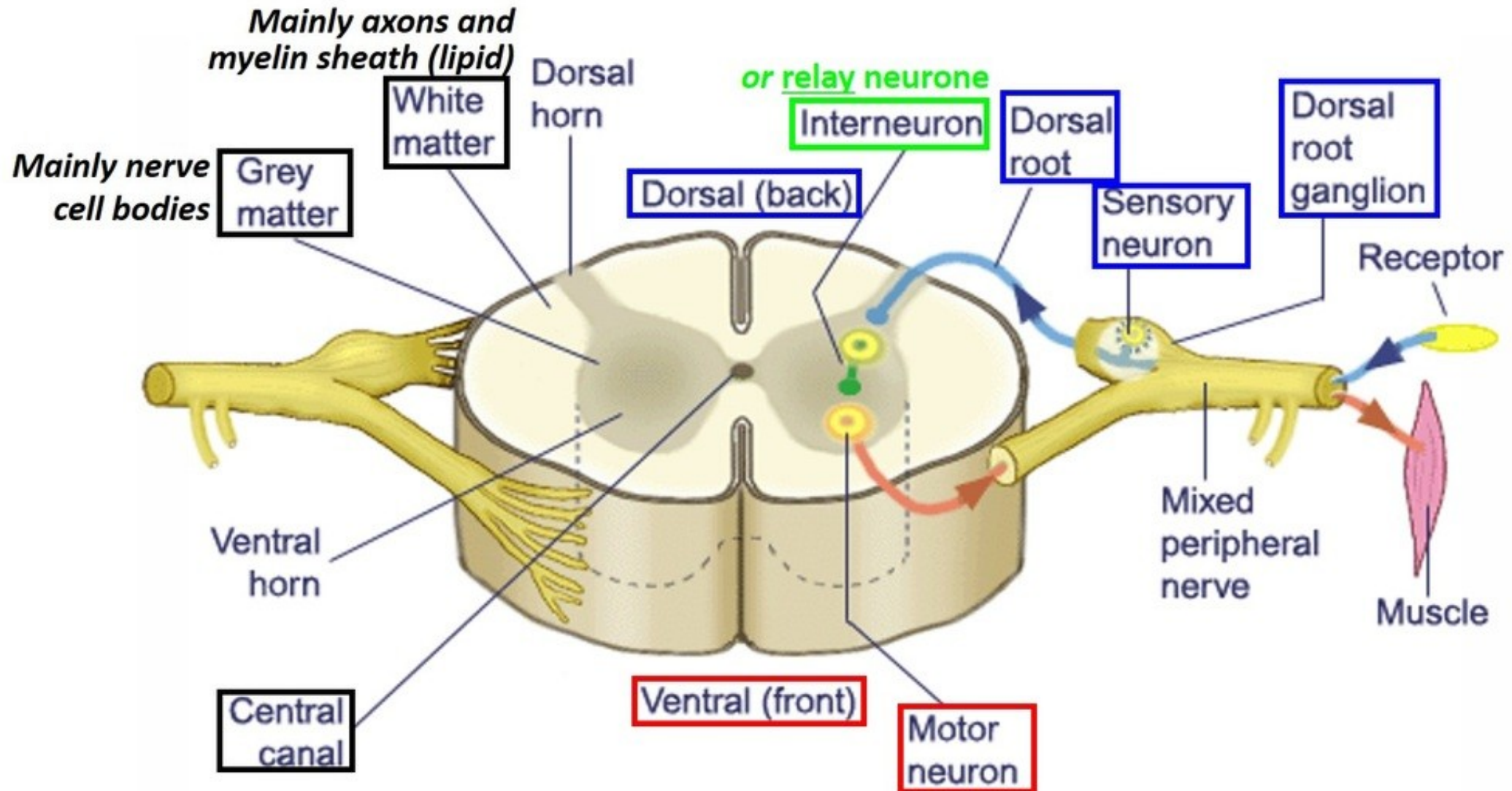
Fig. 2.1. Main features to be seen in a transverse section through the spinal cord.

# General topography of the spinal cord





# The Spinal Cord: structure



# Spinal cord structure



## Gray matter

Central

- **Nerve cells**
- **Unmyelinated nerve fibers**
- **Neuroglia**
- **Blood vessels**

## White matter

Peripheral

- **Myelinated nerve fibers**
- **Neuroglia**
- **Blood vessels**

White matter:

1- **Anterior white column**

2- **Lateral white column**



# **Spinal cord gray matter**

# Spinal cord gray matter

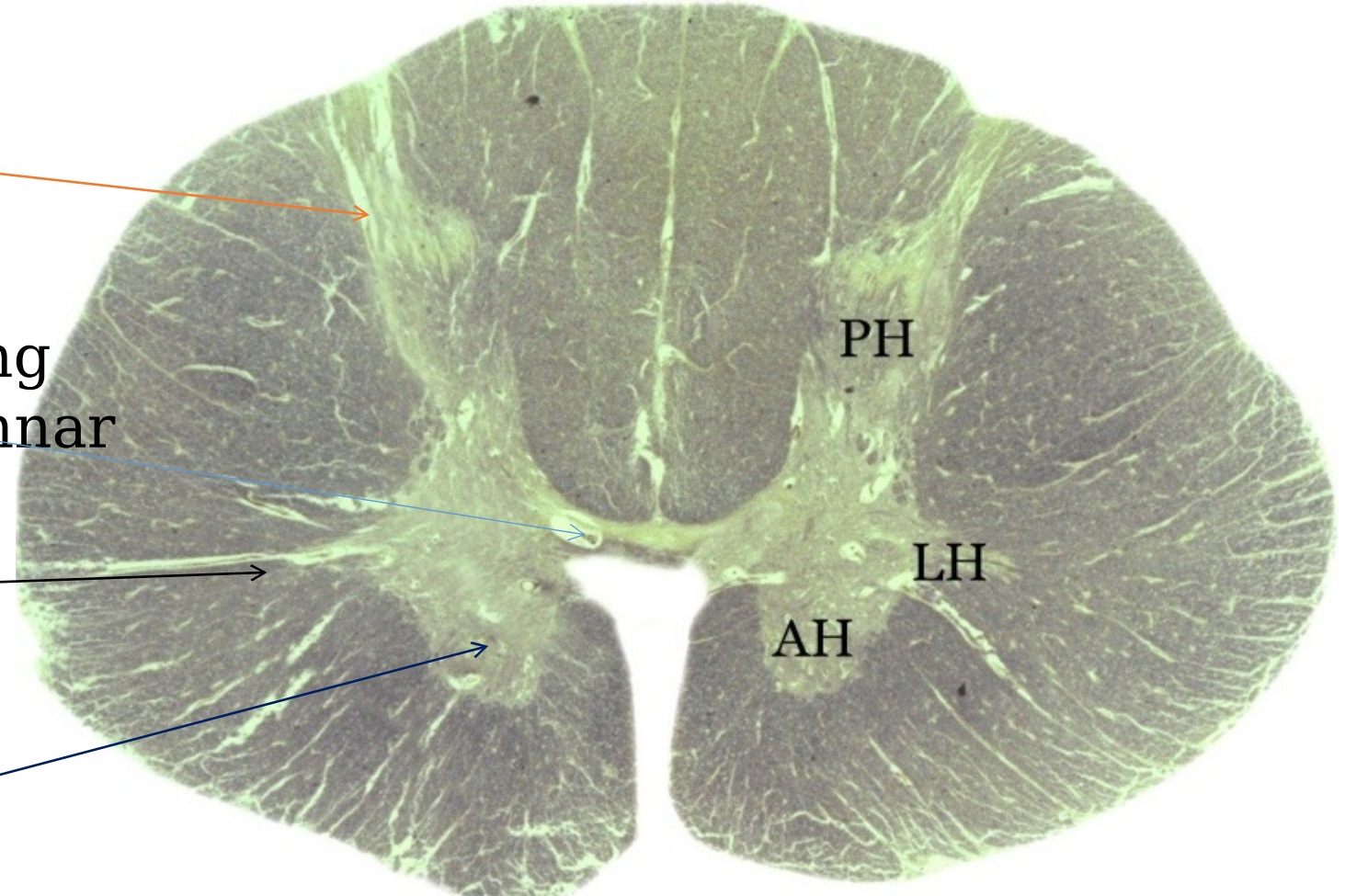


**Posterior  
horns (sensory  
nuclei )**

**Gray commissure** containing  
**central canal** lined by columnar  
ependymal cells

**small lateral horn**  
(T1-L3)

**Anterior horns  
(motor nuclei)**





# Nuclei in gray matter: 1) Dorsal gray column (*sensory nuclei*)



## 1) Dorsomarginal nucleus

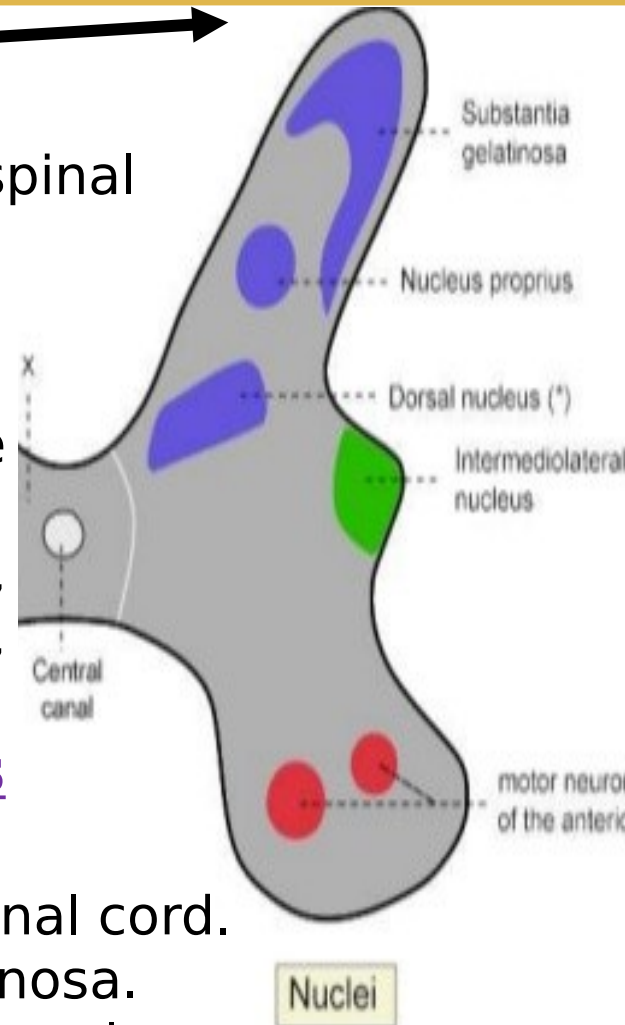
- Capping the dorsal horn
- Extends the entire length of the spinal cord

## 2) Substantia gelatinosa of Rolandi:

- Extends the entire length of the spinal cord.
- Formed of **Golgi type II neurons**, that possess highly branched, unmyelinated axons.

## 3) Nucleus proprius dorsalis (main sensory nucleus):

- Extends the entire length of the spinal cord.
- Just ventral to the substantia gelatinosa.
- Provides input to the lateral and ventral spinothalamic tracts.



## 4) Clark's nucleus (Nucleus dorsalis):

- Intermediate zone of the spinal cord (base of post. Horn)
- Extends from C8-L3
- Large multipolar cells with prominent **Nissl granules**
- Eccentric nucleus.
- Gives DSC tract





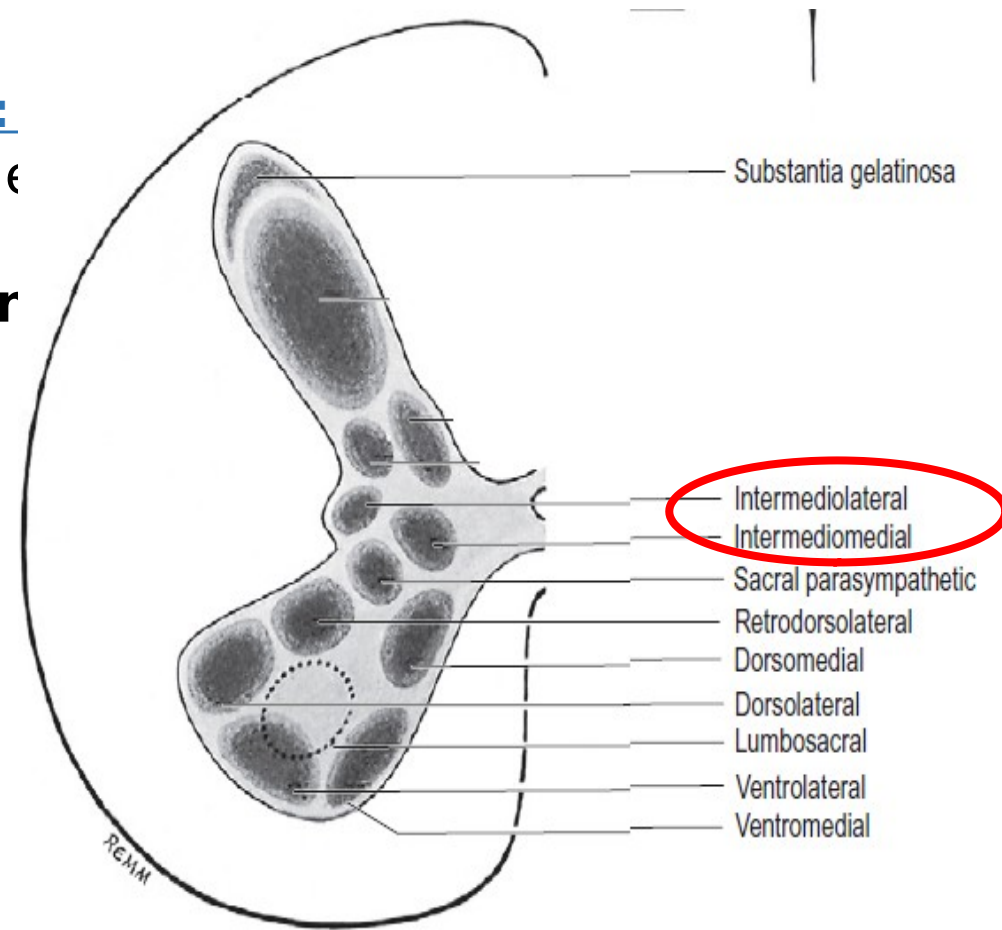
# Nuclei in gray matter: 2) Lateral gray column



## The intermediolateral nucleus:

- Composed of small multipolar cell bodies
- **Between T1 and L2, 3:**  
**Preganglionic sympathetic neurons**
- **Sacral levels S2-S4:**  
**Sacral parasympathetic nucleus**

Embryologically, they developed dorsolateral to the central canal and migrate laterally, forming ***intermediomedial*** and ***intermediolateral*** cell columns



# Nuclei in gray matter: 3) Ventral gray column (*motor nuclei*)



## Medial group

- Extends almost the entire length of the spinal cord.
- Between T1 and L4 it is subdivided into two components, the **dorsomedial** and **ventromedial** groups.
- Provide innervation for the skeletal muscles of the abdomen, the intercostal muscles, and the muscles of the trunk

## Central group

- Present only in the cervical and lumbosacral segments of the spinal cord.
- In the cervical region, there are:
  - **Phrenic nucleus** (C3 to C6)
  - **Accessory nucleus** (C1 to C6).
- In the lumbosacral region:
  - **Lumbosacral group** (L2 to S2)

## Lateral group

- Present only in the regions of the spinal cord responsible for the motor innervation of the upper and lower extremities (C4-T1 and L2-S3).
- Subdivided into:
  - **Ventral group,**
  - **Dorsal group**
  - **Retrodorsal group**

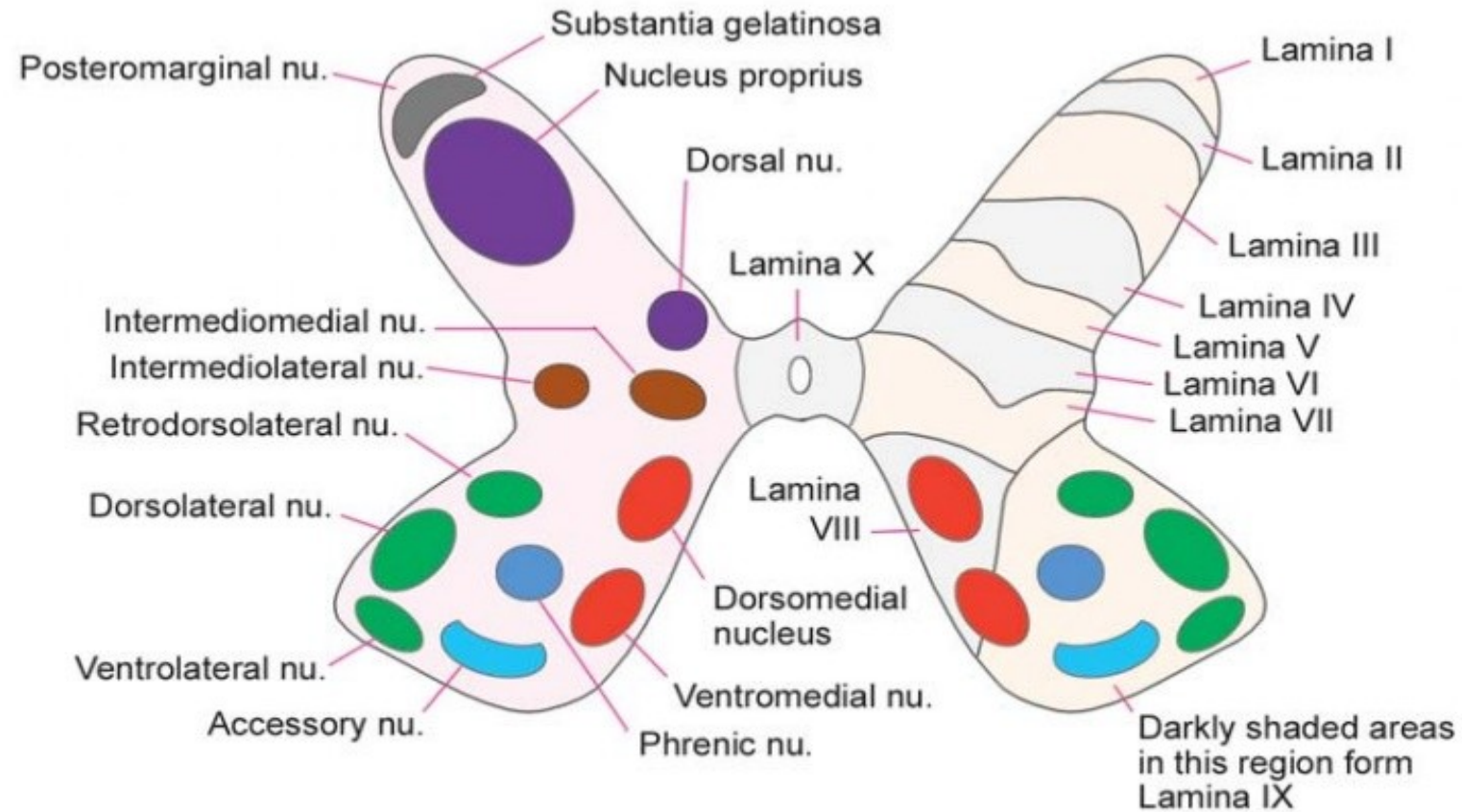


Fig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

<http://www.brainkart.com/media/article/article-Grey-Matter-of-the-S-fvt.jpg>

# Motor nuclei in anterior horn cells

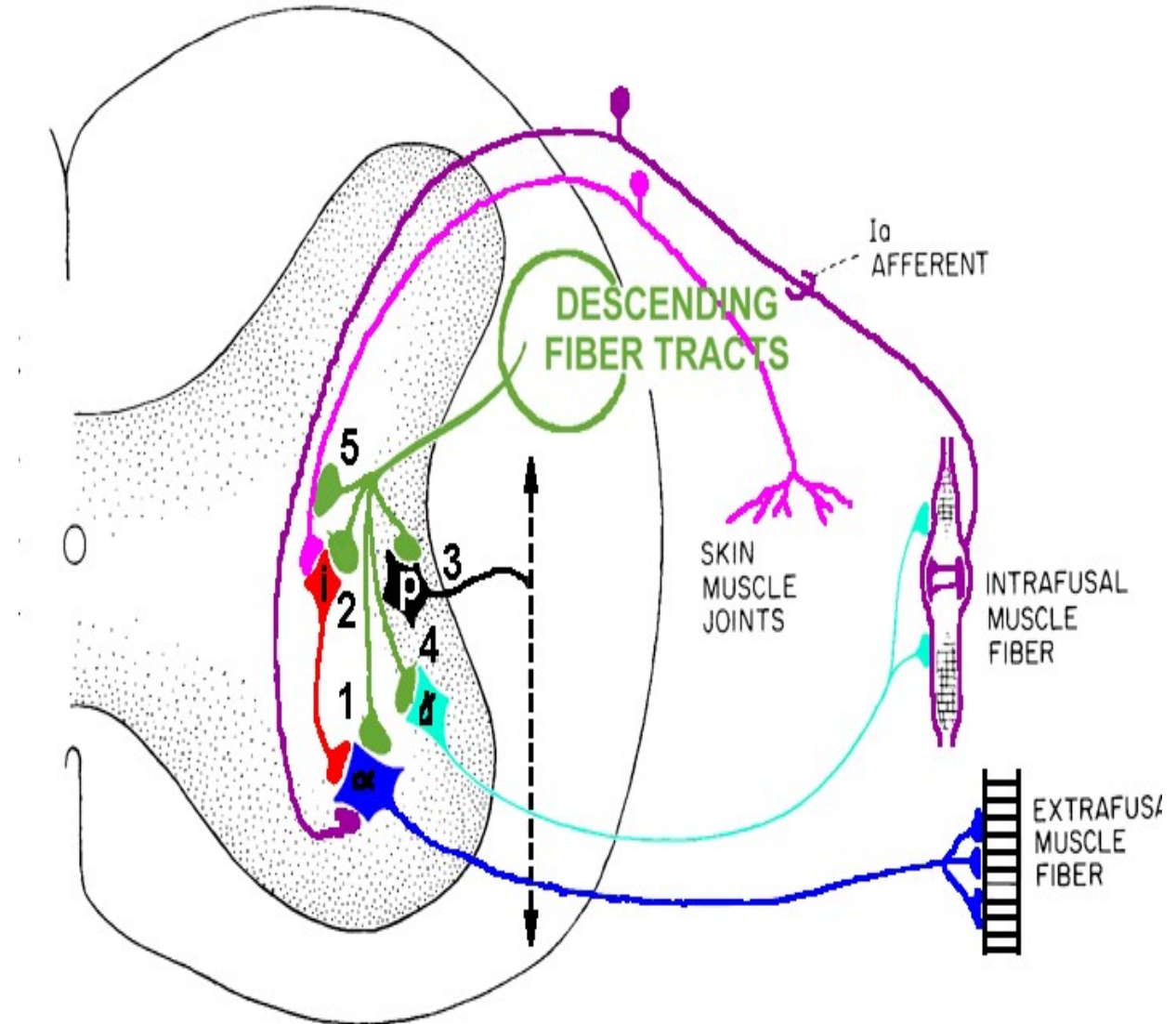


## 1-Alpha $\alpha$ neurons:

- Large cells
- Multipolar
- Prominent Nissl granules.
- Their axons ( $\alpha$  efferents) leave the spinal cord through the ventral roots and innervate skeletal muscle.

## 2- Gamma $\gamma$ neurons:

- smaller cells.
- Their axons ( $\gamma$  efferents) supply intrafusal muscle fibers of





# **Lamination of Spinal cord**



# Rexed's laminae of spinal cord



## Lamina I:

a cap of the posterior horn  
corresponds to **posteromarginal** nucleus

## Lamina II:

a fairly broad band around the apex of  
posterior horn  
corresponds to **substantia gelatinosa**.

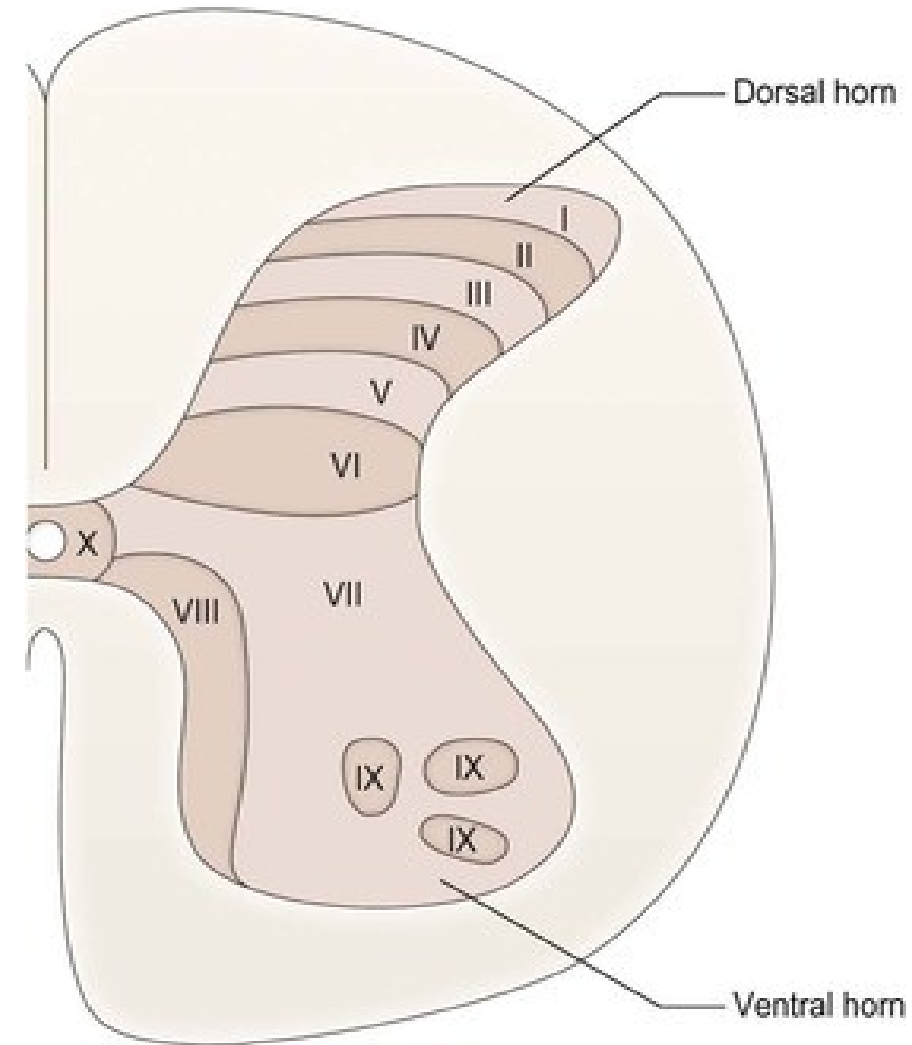
## Lamina III:

band across the posterior horn and is parallel to  
lamina I and II

## Lamina IV:

the thickest lamina extending across the  
posterior horn

**Laminae III and IV correspond to main  
sensory nucleus**



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# Rexed's laminae of spinal cord

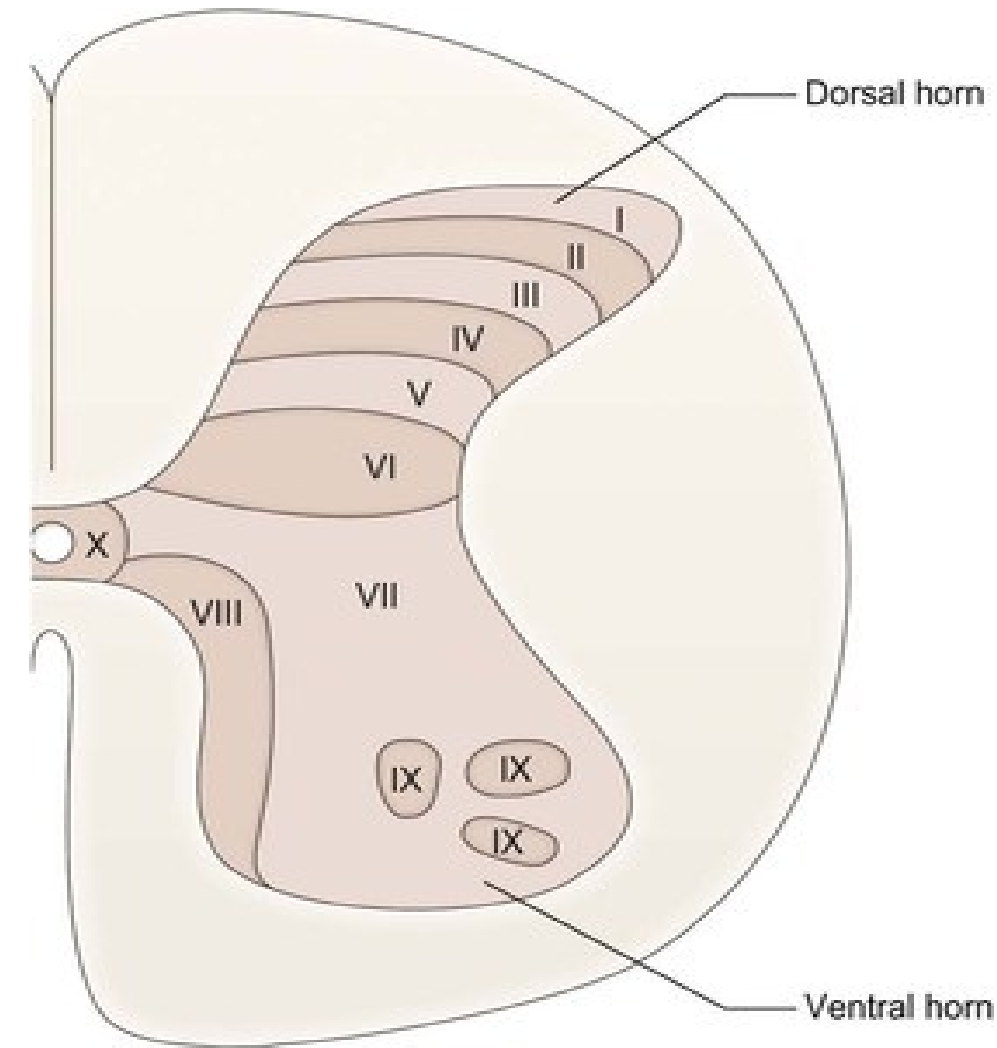


## Lamina V:

- **neck** of the dorsal gray column
- Houses thick bundles of nerve fibers
- Its lateral aspect is referred to as the *formation reticularis*.

## Lamina VI:

- Corresponds to the base of the dorsal horn.
- Prominent in the limb enlargements.
- Medial part contains of small, densely packed neurons while, the lateral part contains larger, more loosely packed neurons.



[https://neupsykey.com/wp-content/uploads/2016/07/c00008\\_f008-010-97807\\_02054051.jpg](https://neupsykey.com/wp-content/uploads/2016/07/c00008_f008-010-97807_02054051.jpg)

# Rexed's laminae of spinal cord



## Lamina VII:

Intermediate gray includes:

- 1) **Clarke's nucleus**
- 2) **Intermedio-medial** nucleus
- 3) **Intermedio-lateral** nucleus: in the **lateral** horn in T1 - L2.

## Lamina VIII

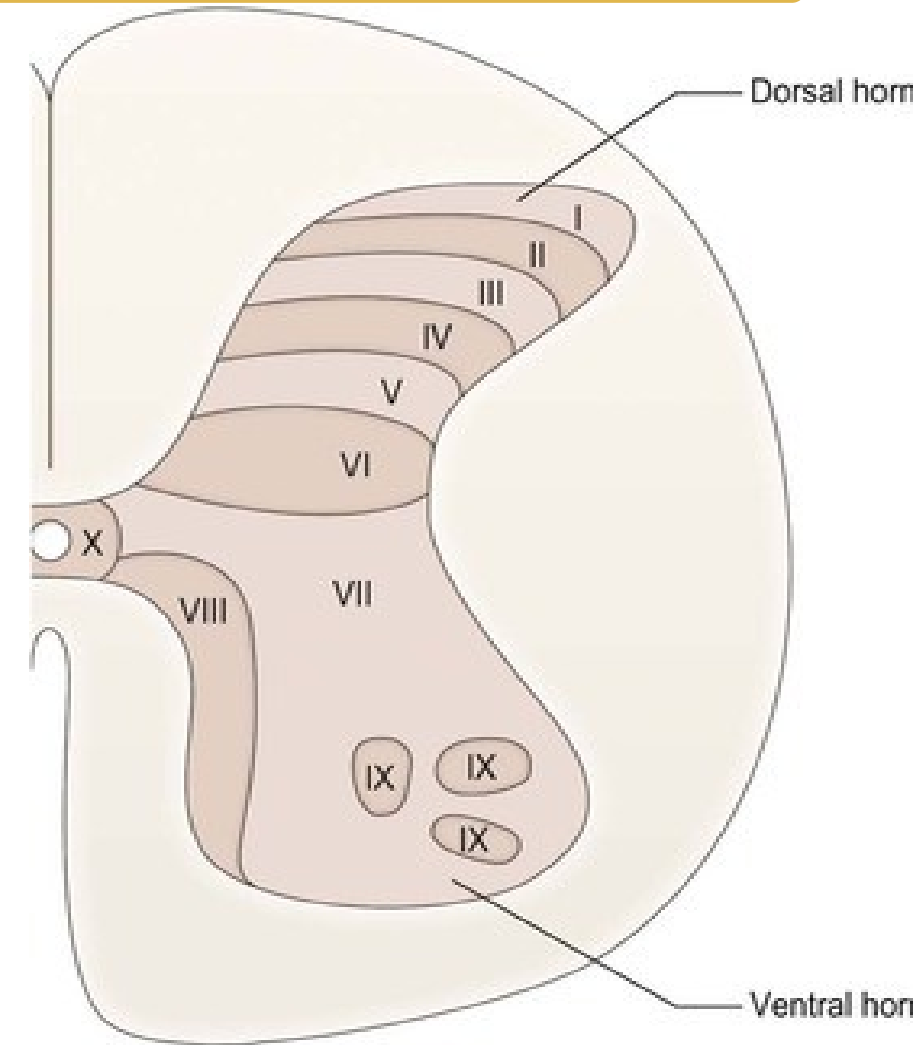
Starts at base of anterior horn, varies in size in different levels.

## Lamina IX:

Motor nuclei ( $\alpha$  and  $\gamma$  motor neurons)

## Lamina X:

forms the gray matter **around** the central canal.



# Lamination of gray matter



Postromarginal nucleus	Lamina I
Substantia gelatinosa	Lamina II
Main sensory nucleus	Lamina III
Main sensory nucleus	Lamina IV
Reticular formation	Lamina V
Interneuronal neurons	Lamina VI
Clark's, intermediomedial, intermediolateral nuclei	Lamina VII
Base of anterior horn	Lamina VIII
M & L groups of motor nuclei	Lamina IX
Grey matter around the central canal	Lamina X



# **Spinal cord white matter**



# Tracts of white matter



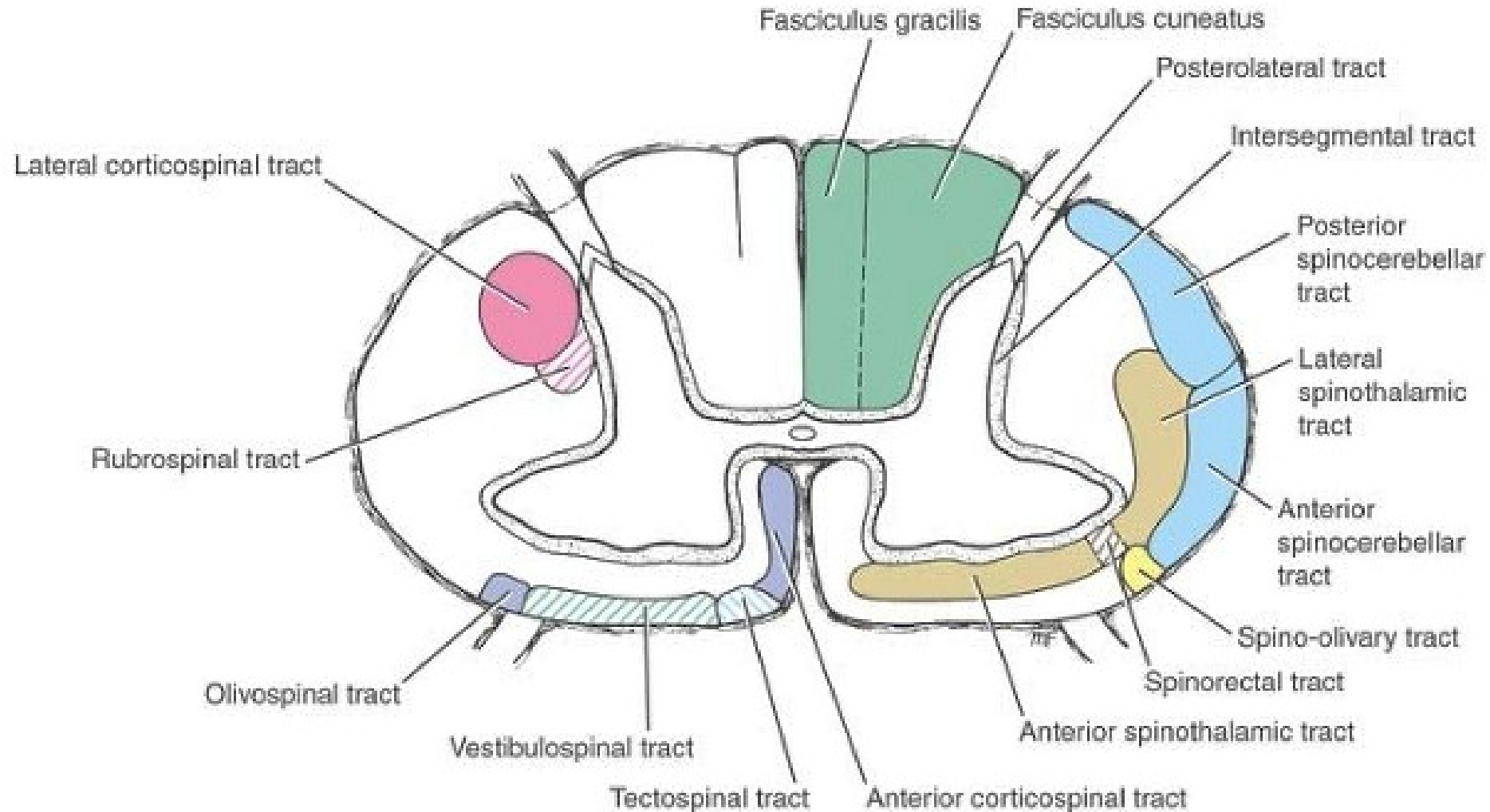
Tracts of white column are classified into three categories; ascending, descending, and intersegmental.

**Ascending tracts:** transmit sensory information to higher centers  
(sensory)

**Descending tracts:** relay motor information originating at higher  
centers (motor)

**Intersegmental tracts:** convey information between spinal cord

# Tracts of white matter



# Ascending tracts of white matter



- On entering the spinal cord, the sensory nerve fibers of different sizes and functions are segregated into tracts in the white matter.
- The ascending tracts conduct afferent information (may or may not reach consciousness).

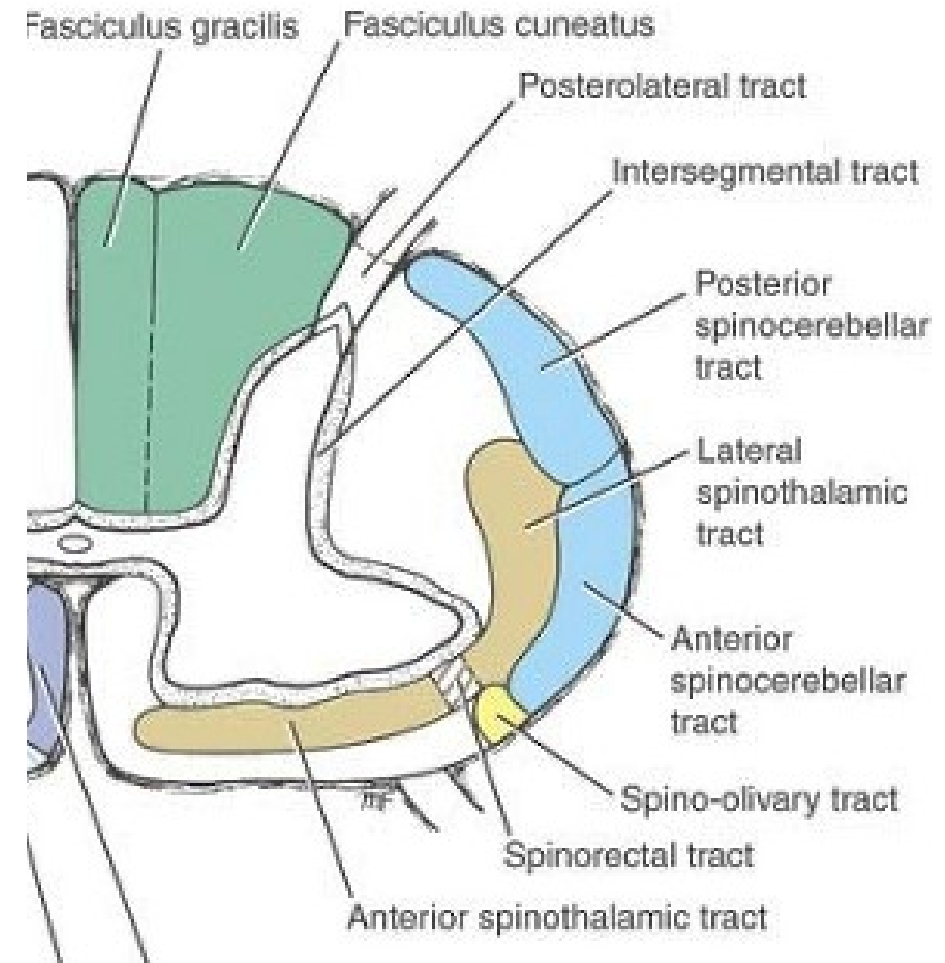
The afferent information are divided into two main groups:

- (1) ***Exteroceptive information***, (originates from outside the body): pain, temperature, and touch
- (2) ***Proprioceptive information***, (originates from inside the body): from muscles and joints.

# Ascending tracts of white matter



Dorsal funiculus	Lateral funiculus	Anterior funiculus
Gracil tract	Dorsal spinocerebellar	Ventral spinothalamic
Cuneate tract	Ventral spinocerebellar	
	Lateral spinothalamic	
	Spino-tectal	
	Spino-olivary	



# Descending tracts of white matter



- The nerve fibers that descend in the white matter from different supraspinal nerve centers are segregated into nerve bundles called the descending tracts.
- These supraspinal neurons and their tracts are sometimes referred to as the upper motor neurons.



# Descending tracts of white matter



Fast

**Dorsal  
funiculus**

**Lateral  
funiculus**

**Anterior  
funiculus**

Lateral cortico-  
spinal

Ventral  
corticospinal

Rubro-spinal

Vestibulospinal

Olivospinal

Tectospinal

Reticulospinal

Lateral corticospinal tract

Rubrospinal tract

Olivospinal tract

Vestibulospinal tract

Tectospinal tract



## **Spinal cord levels**

# Spinal cord levels



## Segments of the spinal cord

I- **Cervical** segments

II- **Thoracic** segments including:

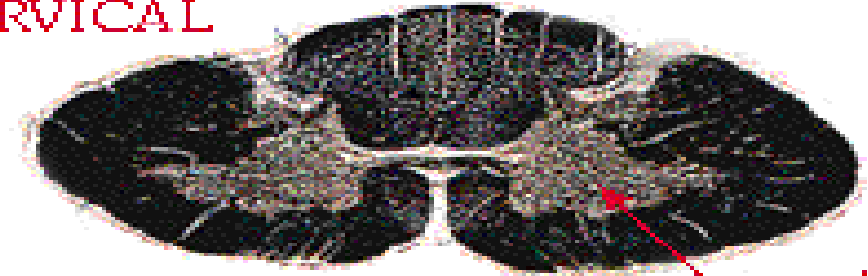
1- **Upper** thoracic segments  
and

2- **Lower** thoracic segments

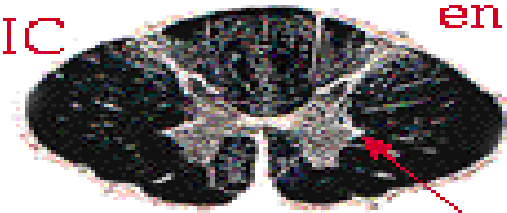
III- **Lumbar** segments

IV- **Sacral** segments

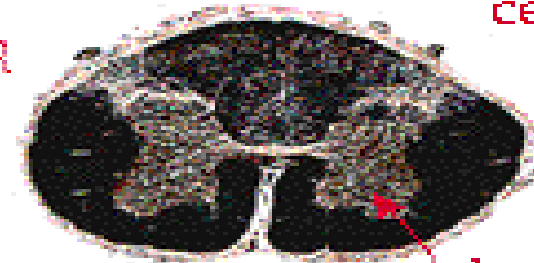
CERVICAL



THORACIC



LUMBAR



SACRAL



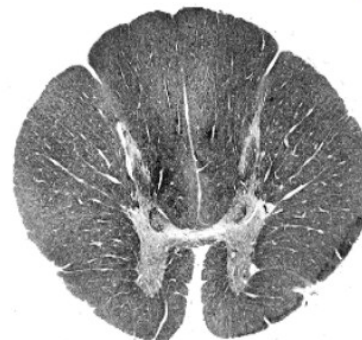
# Spinal cord levels



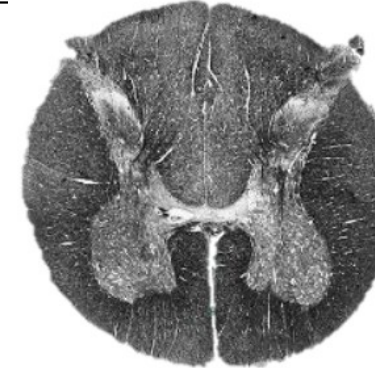
<b>Sacral</b>	<b>Lumber</b>	<b>Thoracic</b>	<b>Cervical</b>	
Small	Large	Small	Large	<b>Size</b>
Rounded	Rounded	Rounded	Oval	<b>Shape</b>
Thick	Thick	Thin	<b>Thin, divergent</b>	<b>Posterior horn</b>
<b>Thick</b>	<b>Thick</b>	<b>Thin</b>	<b>Thick</b>	<b>Anterior horn</b>
<b>No</b>	<b>NO</b>	<b>Present</b>	<b>No</b>	<b>Lateral horn</b>
Few	Less than cervical	Less than cervical	<b>Greater in amount</b>	<b>White matter</b>



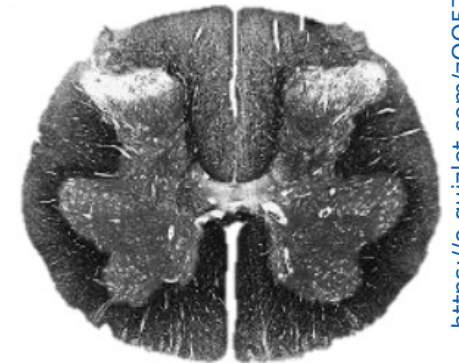
Cervical



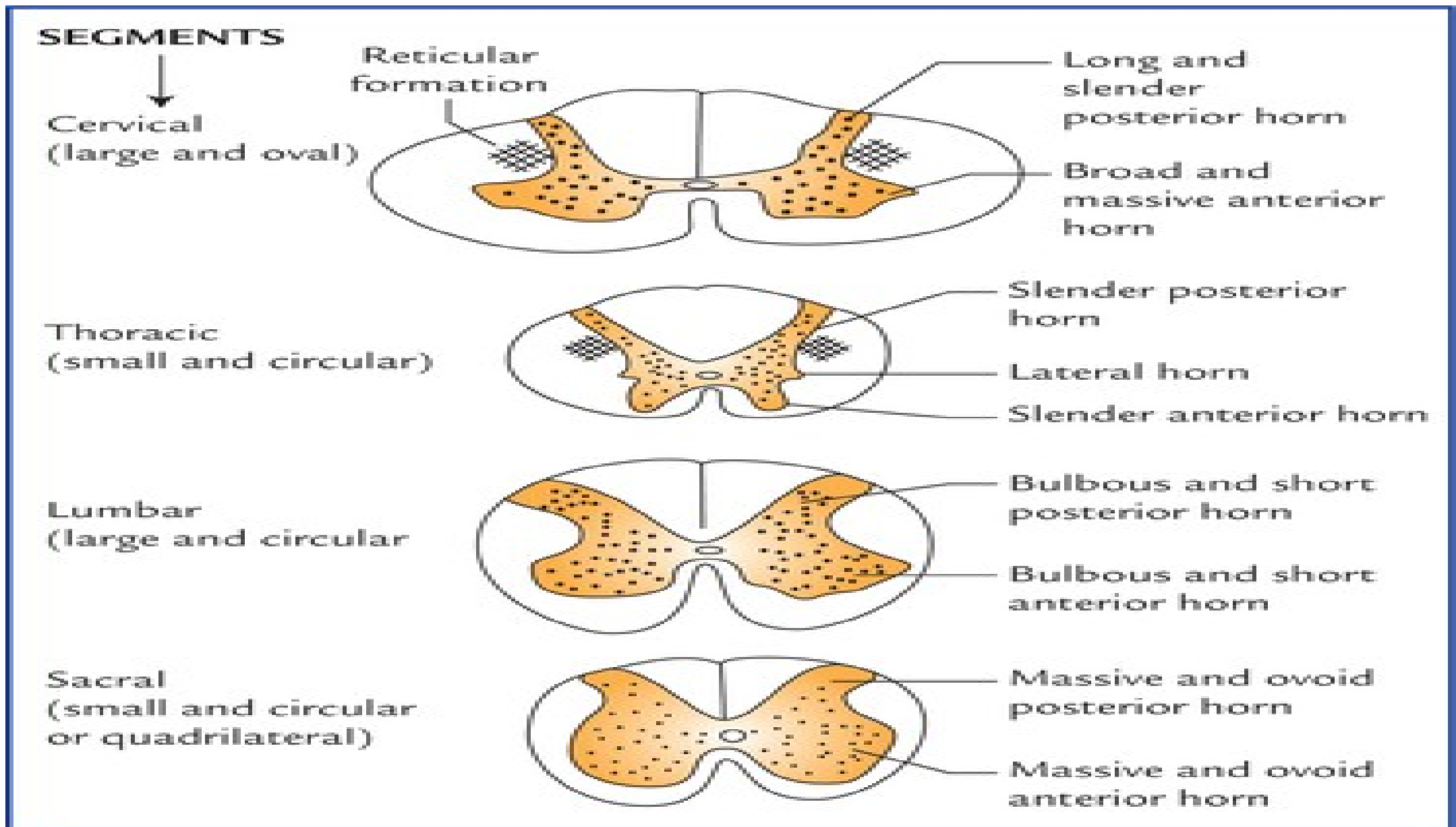
Thoracic  
neuroscience module



Lumbar

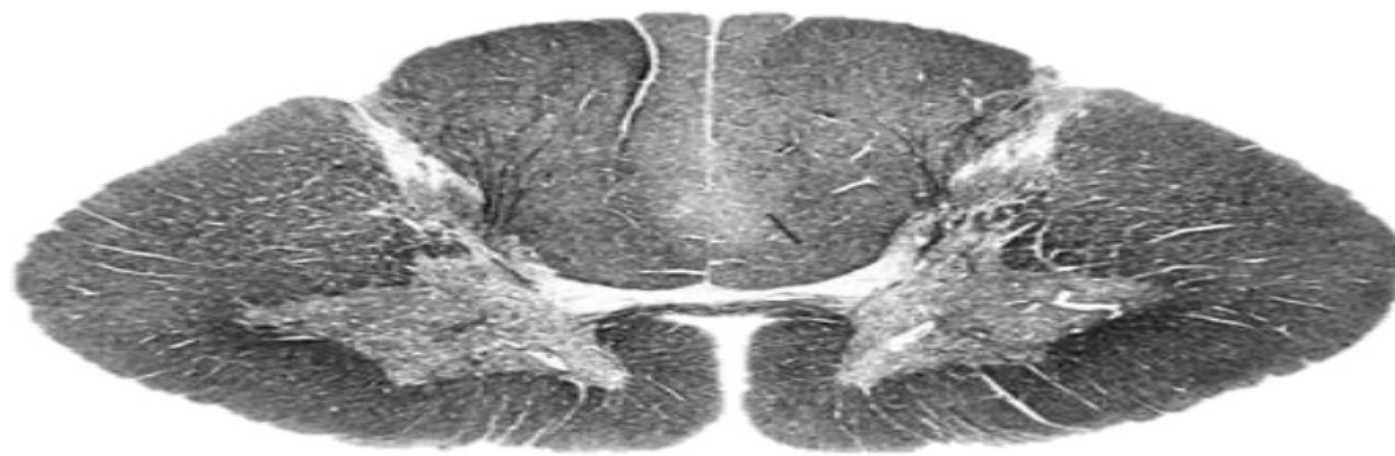


Sacral



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on the



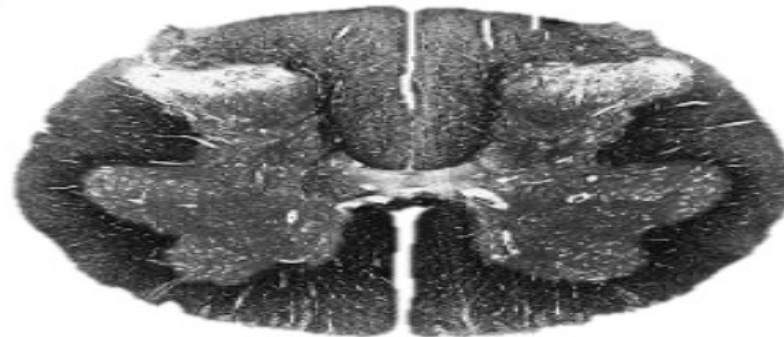
**Cervical**



**Thoracic**



**Lumbar**



**Sacral**



# Spinal nerves

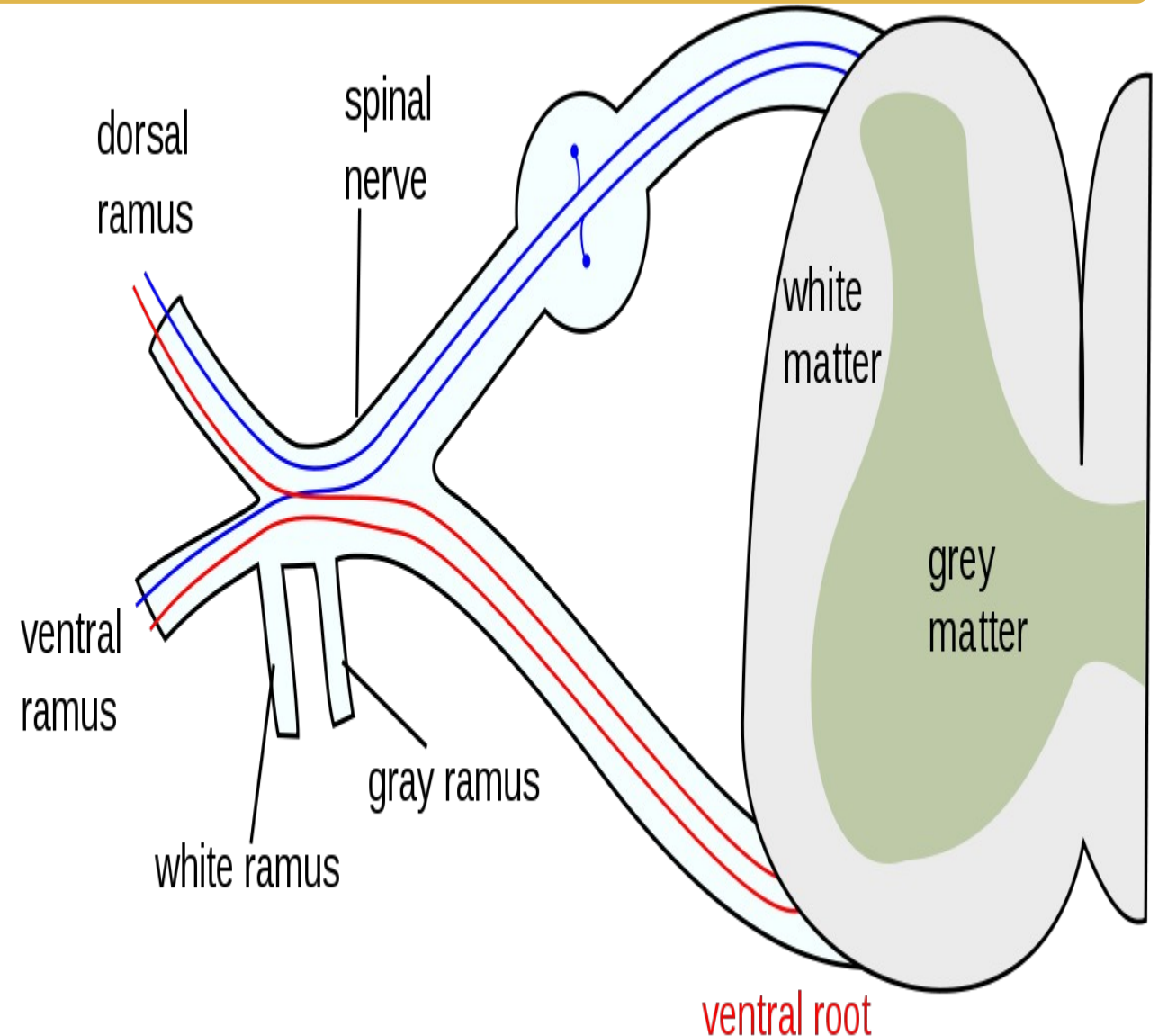
dorsal root



Each spinal nerve is attached to the spinal cord by 2 roots:

**1- Dorsal root : purely sensory (afferent)**

**2- Ventral root : purely motor (efferent)**



# Spinal nerves



## A- Dorsal root

3 types of nerve fibers:

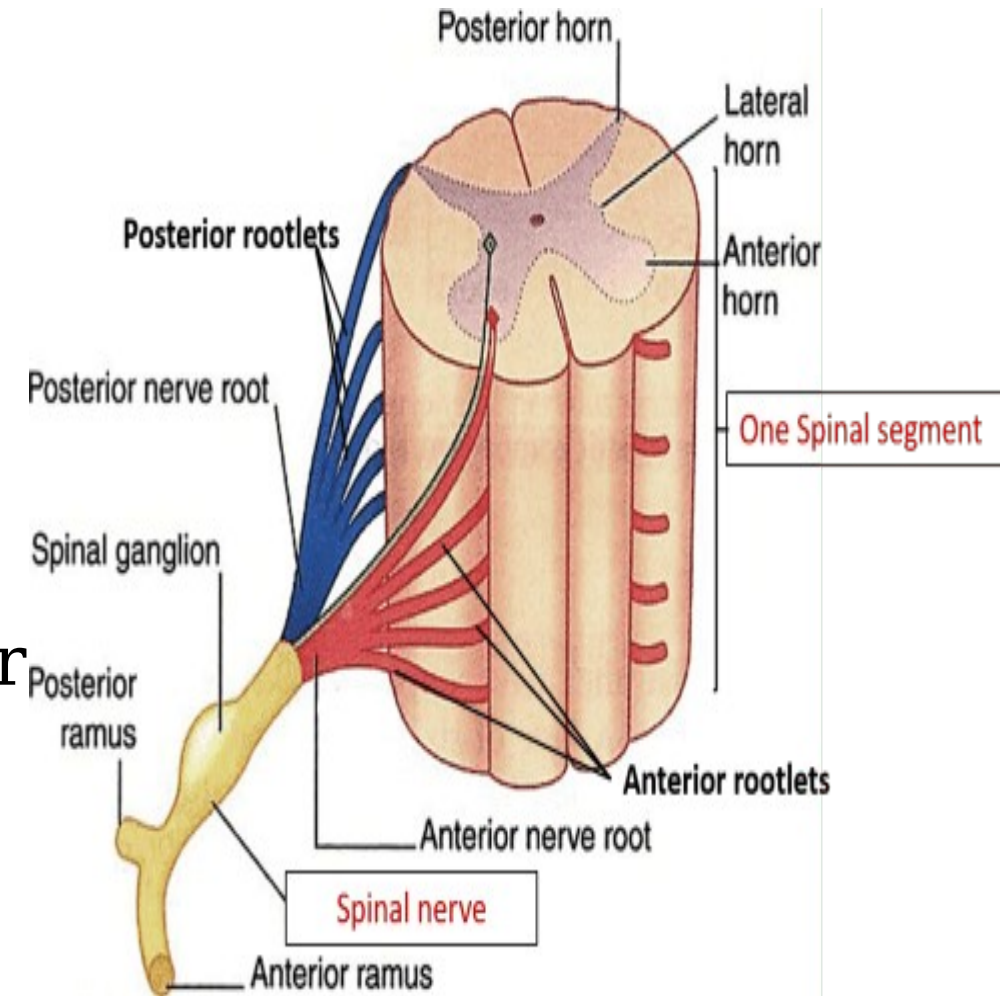
1- **Thin unmyelinated** (pain and temperature )

2- **Medium-sized myelinated** nerve fiber (touch )

3- **Thickly myelinated** nerve fibers (proprioceptive )

## B- Ventral root:

motor nerve fibers of 2 types of neurons:  
neurons



alpha ( $\alpha$ )

gamma ( $\gamma$ )

# Dorsal root ganglion



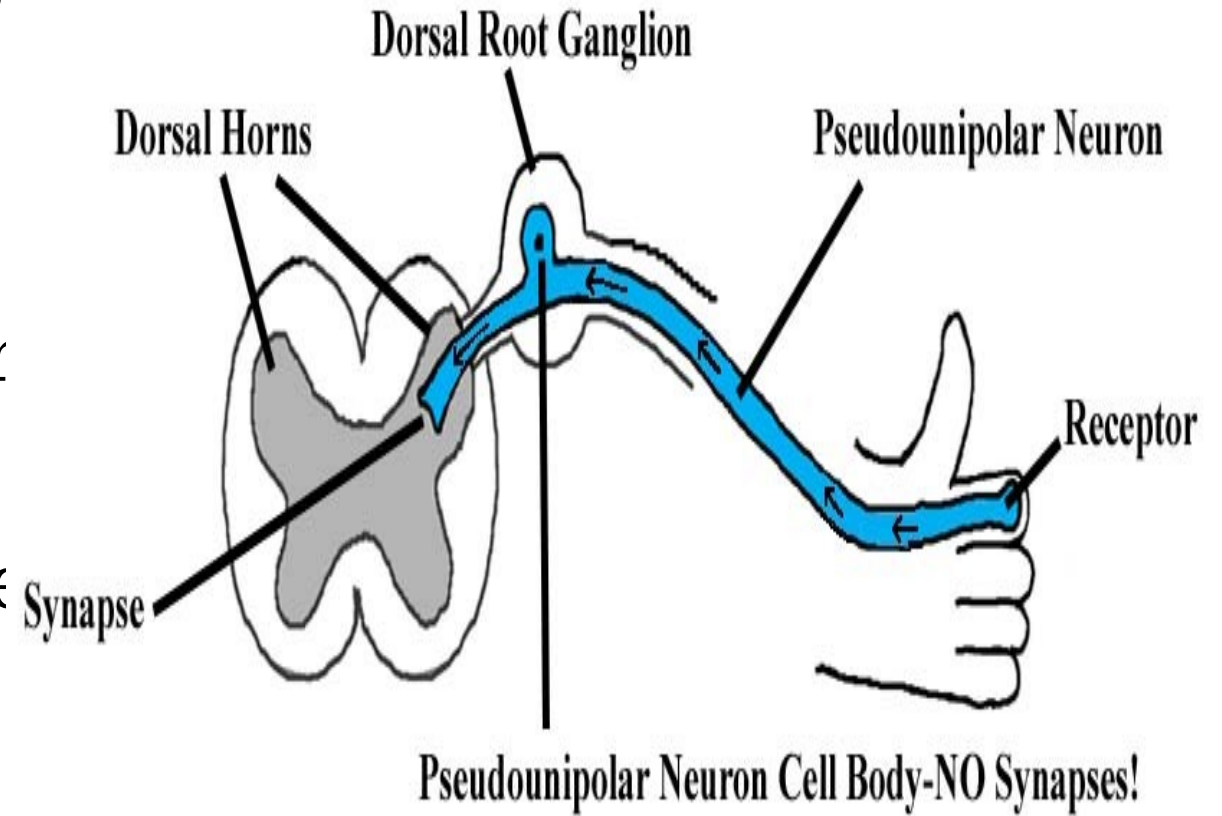
It is the **first order neuron** of all sensations.

It contains **3** types of cells

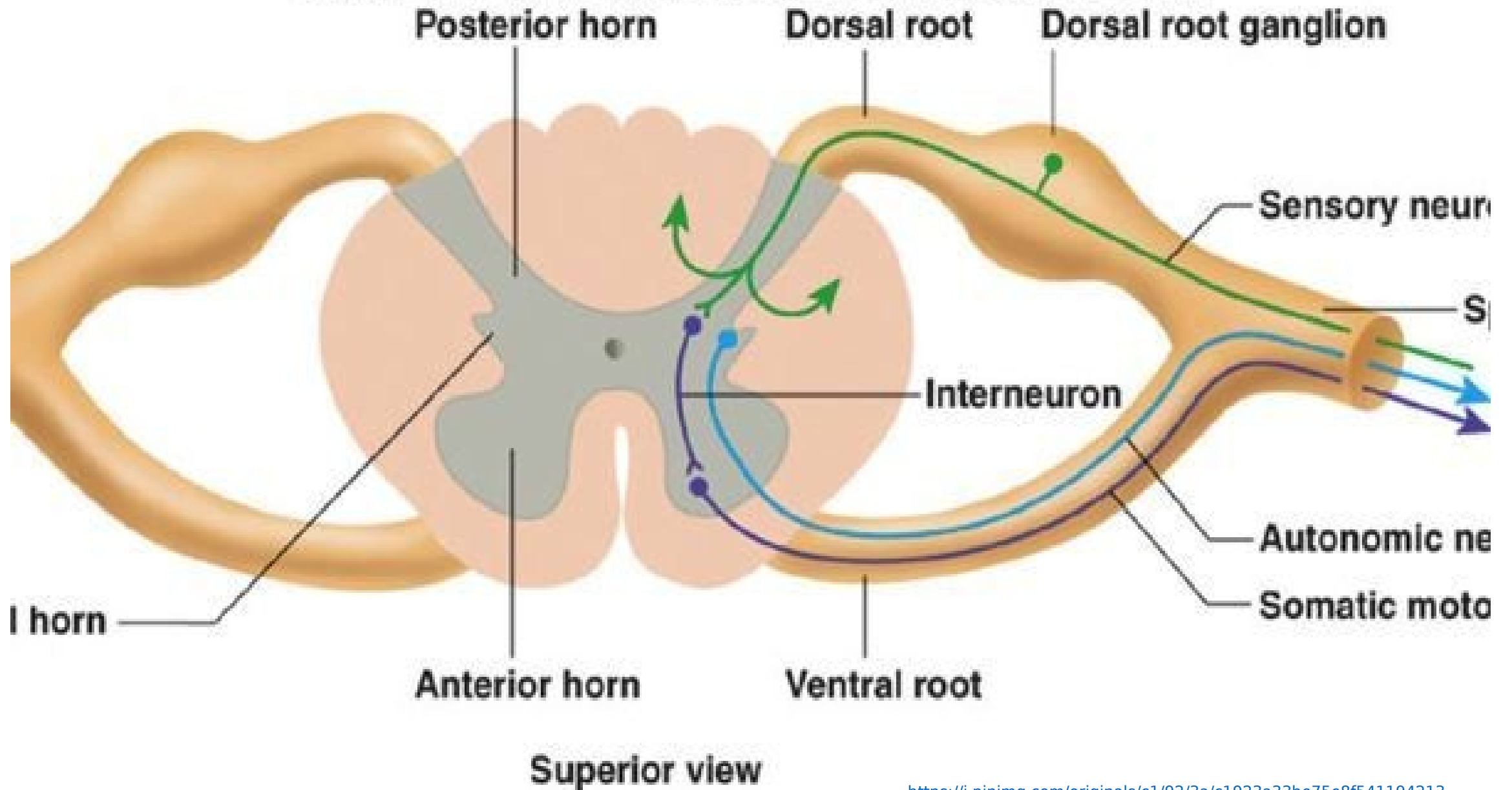
A- **Small** cells receive **pain** and **temperature**

B- **Medium** sized cells receive **touch** sensation

C- **Large** cells receive **proprioceptive** sensation



[https://anatomy.elpaso.ttuhsu.edu/modules/spinal\\_cord\\_module/Files/pseudounipol.jpg](https://anatomy.elpaso.ttuhsu.edu/modules/spinal_cord_module/Files/pseudounipol.jpg)



<https://i.pinimg.com/originals/c1/92/3a/c1923a33be75e8f5411942136c39eb90.jpg>

# Quiz



**Posterior gray horn of cervical levels is characterized by -1  
?which of the following**

- a) thick & divergent
- b) thick & convergent
- c) thin & divergent
- d) thin & convergent

**?Lamina II corresponds to which gray nuclei -2**

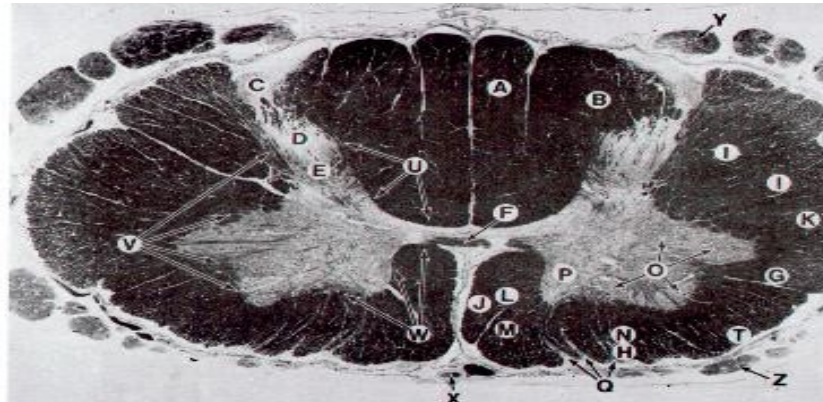
- a) Posterior marginal nucleus
- b) Alpha motor nuclei
- c) Main sensory nucleus
- d) Substantia gelatinosa of Rolandi

# Quiz

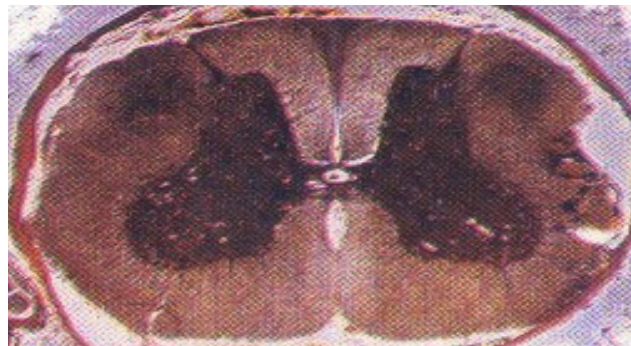


Name the following levels

1-



2-

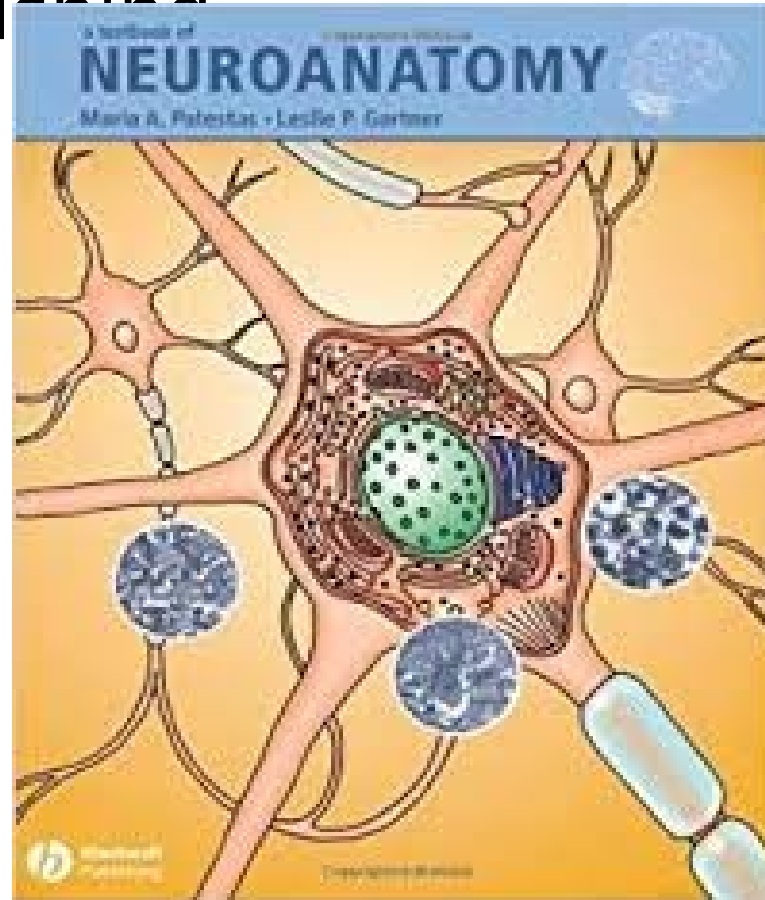




# Suggested text books



**A Textbook of Neuroanatomy (2006):** Maria A. Patestas and Leslie P. Gartner (eds). Chapter 5: Spinal cord **PP.: 50-63.** Blackwell Publishing.





Thank  
you

